Claims

What is claimed as new and desired to be protected by Letters Patent of the United States is:

1. A method of obtaining the instantaneous phase of a sinusoidal periodical signal, comprising:

    generating a plurality of phase shifted replicas of the sinusoidal signal;

    converting the phase shifted sinusoidal signals into time delayed square shaped signals;

    comparing the transition times of the square shaped signals with the transition time of a reference clock;

    determining which transitions of the square shaped signals occurs before and after the transition of the reference clock;

    converting the resulting information into a digital code.

2. A method as in claim 1, wherein the plurality of phase shifted replicas of the sinusoidal signal comprises of n sinusoidal signals phase shifted with regards to each other by the amount of $180°/n$.

3. A method as in claim 1, wherein the conversion of the plurality of phase shifted sinusoidal signals into square shaped signals is executed using hard limiting electronic devices or high gain amplifiers or digital comparators.

4. A method as in claim 1, wherein the determination of the timing of transitions in the square shaped signals is done using a flip-flop or a sampling device.

5. A method as in claim 1, wherein the conversion of the output of the flip-flops or sampling devices into a digital code is obtained using EXOR functions.

6. A method as in claim 1, wherein the digital code resulting from the code conversion may be a Gray code or a binary code.

7. An apparatus to determine the instantaneous phase of two sinusoidal signal in quadrature, comprising:

    Two input buffers one for each of the quadrature related sinusoidal signals;

    Two resistive networks each comprised of n-1 resistors having n taps;

    An array of n comparators each having two differential inputs wherein one input connects to one tap on one resistive network and wherein the other input connects to one tap on the other resistive network;

    An array of n flip-flops each having an input connecting to one output of a comparator and wherein a reference clock connects to all the flip-flops;

    An array of Exclusive OR gates connecting to the outputs of the flip-flops to generate a digital code

8. An apparatus as in claim 7, wherein one end of each resistive network connects to the output of one input buffer and wherein the other end of that resistive network connects to ground.

9. An apparatus as in claim 7, wherein n taps on each resistive network include the output of the input buffer and ground.

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10. An apparatus as in claim 7, wherein the digital output code is a Gary code.

11. An apparatus as in claim 7, wherein the digital output code is a Binary code.

12. An apparatus to determine the instantaneous phase of a complex signal, comprising:

An input amplifier;

A hard limiting device;

A buffer;

A low-pass filter;

A quadrature signal divider;

Two input buffers one for each of the quadrature related sinusoidal signals;

Two resistive networks each comprised of n-1 resistors having n taps;

An array of n comparators each having two differential inputs wherein one input connects to one tap on one resistive network and wherein the other input connects to one tap on the other resistive network;

An array of n flip-flops each having an input connecting to one output of a comparator and wherein a reference clock connects to all the flip-flops;

An array of Exclusive OR gates connecting to the outputs of the flip-flops to generate a digital code

13. An apparatus as in claim 12, wherein the digital output code is obtained in a two step sequence utilizing EXOR functions.

14. An apparatus as in claim 12, wherein a hard limiter comprises limiting diodes or high gain saturated amplifiers.

15. An apparatus as in claim 12, wherein the frequency range of operation is defined by the low-pass filter.

16. An apparatus as in claim 12, wherein a quadrature signal divider comprises a hybrid coupler or an RC / CR phase shifting network.

17. An apparatus to determine the instantaneous phase of two sinusoidal signal in quadrature, comprising:

Two input buffers one for each of the quadrature related sinusoidal signals wherein each buffer comprises two differentially complementary linear outputs;

An array of n comparators each having two differential inputs wherein each input connects to two resistors and wherein one said resistors connects to one output of one buffer and the second said resistor connects to one output of the second input buffer;

An array of n flip-flops each having an input connecting to one output of a comparator and wherein a reference clock connects to all the flip-flops;

An array of Exclusive OR gates connecting to the outputs of the flip-flops to generate a digital code

18. An apparatus as in claim 17, wherein the digital output code is a Gary code.

19. An apparatus as in claim 17, wherein the digital output code is a Binary code

20. An apparatus as in claim 17, wherein the digital output code is obtained in a two step sequence utilizing EXOR functions.

21. An apparatus to determine the instantaneous phase of a complex signal, comprising:

An input amplifier;

A hard limiting device;

A buffer;

A low-pass filter;

A quadrature signal divider;

Two input buffers one for each of the quadrature related sinusoidal signals wherein each buffer comprises two differentially complementary linear outputs;

An array of n comparators each having two differential inputs wherein each input connects to two resistors and wherein one said resistors connects to one output of one buffer and the second said resistor connects to one output of the second input buffer;

An array of n flip-flops each having an input connecting to one output of a comparator and wherein a reference clock connects to all the flip-flops;

An array of Exclusive OR gates connecting to the outputs of the flip-flops to generate a digital code

22. An apparatus as in claim 21, wherein the digital output code is a Gary code.

23. An apparatus as in claim 21, wherein the digital output code is a Binary code

24. An apparatus as in claim 21, wherein the digital output code is obtained in a two step sequence utilizing EXOR functions.

25. An apparatus to determine the instantaneous phase of a complex signal utilized in an instantaneous frequency measurement apparatus.

26. An apparatus to determine the instantaneous phase of a complex signal utilized in digital RF memories.

27. An apparatus to determine the instantaneous phase of a complex signal utilized in signal restoration circuits.

Abstract

The present invention provides a new and efficient way of measuring the instantaneous phase of periodic signals. The instantaneous phase information is also applicable to new methods of instantaneous frequency measurements, and signal frequency restoration.